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INCREASED PRICE

of the

N.A.A.S. QUARTERLY REVIEW

It is regretted that owing to increased production costs the price of the N.A.A.S. QUARTERLY REVIEW has had to be raised, as from the Spring 1952 issue, to 1s. 6d. (1s. 8d. by post). Annual subscription rates will be adjusted accordingly to 6s. 6d. including postage.

Current subscriptions will be subject to the new rates on renewal.

ARTICLE

PROBLEMS CONCERNING THE COMPOSITIONAL QUALITY OF MILK

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Of recent years there have been increasing demands for advisory work on the compositional quality of milk as distinct from its hygenic and keeping qualities arising from the more frequent occurrence of genuine milk of low fat and more especially low solids-not-fat content. At the same time further research has been stimulated into the circumstances which influence milk composition and into the decline which has, unfortunately, taken place over a number of years in the composition of the milk produced in this country. The object of this review is to describe the problems of milk composition, to give an account of the investigations which have been carried out, and to discuss and summarize the present information on the subject.

Composition of Milk—Past and Present

During the first thirty years of the century the average composition of milk was reported, by various authorities [1,2] and for different parts of the country, as from 3.61 to 3.75 per cent fat and 8.89 to 8.91 per cent solids-not-fat, but in the last twenty to twenty-five years, as investigations by the National Institute for Research in Dairying [3,4,5] and the Milk Marketing Board[6,7] have shown, the average composition has declined to about 3.55 per cent fat and 8.65 per cent solids-not-fat, the fat percentage falling by between 0.05 and 0.10 and the solids-not-fat percentage by about 0.25. The fall in solids-not-fat is due almost entirely to a fall in the valuable protein content of the milk. These changes may at first sight seem small, but, as is well recognized, milk plays a most important part in our national dietary and if the former compositional quality had been maintained there would, on the basis of the 1,580 million gallons of milk sold off farms in England and Wales last year, be available for human consumption an additional 18,000 tons of non-fatty solids (proteins, carbohydrate, minerals, etc.), including 14,000 tons of protein of high biological value, and additional butter fat, annually.

Apart from its human nutritional bearings, however, the occurrence of genuine milk with a low content of fat or solids-not-fat creates difficulties for the milk producer under the requirements of his contract, and for the producer, creamery and distributor alike, with the standards of the sale of milk regulations. These difficulties will be

appreciated on considering the seasonal variations in the composition of bulk milk and of the milk of individual herds.

Seasonal and Herd Variations

The fat content of milk follows a simple seasonal trend ; it is highest in October and November, averaging 3.8 to 3.9 per cent, and lowest in May and June, at 3.3 to 3.4 per cent. Creamery bulk milks in general therefore have appreciable latitude over the presumptive standard of 3.0 per cent, but there are some areas where the fat content of the creamery bulks falls uncomfortably close to the standard in the spring months. Also, little difficulty is experienced by the majority of herds in producing, even in the spring, a mixed morning-evening milk up to the rather low standard, but fat problems with individual herds, as will be discussed later, often arise at this and other times.

The seasonal changes in the solids-not-fat content of milk are more complex and vary in detail for different parts of the country. In the western and midland areas of England and in Wales the solids-not-fat content is relatively high in October and November, falls steadily to a minimum in April or early May, rises in May to what is usually the highest level of the year in May and June, and falls again to some extent in July or August. In illustration of the range, typical figures are : October and November, 8.73 ; April, 8.55 ; May and June, 8.75-8.80 ; and July or August, 8.65 per cent. Thus, in these traditional milk-producing areas the greatest difficulty with solids-not-fat is in the late winter months ; and it is most pronounced at this time in the west, where the solids-not-fat content of creamery bulks may then fall below 8.5 per cent—in some instances to 8.4 per cent. In the eastern counties the seasonal trend differs in that the depression of solids-not-fat content is much less in the winter and greater in the summer, with, in fact, the lowest levels usually occurring in August[7].

The critical position which arises from the average solids-not-fat content of our bulk supplies being at 8.65 per cent, so very close to the legal standard and from the concomitant seasonal variations, is further shown by the variation in the solids-not-fat content of the milk of individual herds. These cover a wide range and at any given time in any area are distributed more or less normally around the mean value. The resulting high incidence of low solids-not-fat is well summarized by the data in Table 1 which were reported by Provan[7] from a study of the milk received at the Milk Marketing Board's creameries in the years 1944-47. They indicate the percentage of producers likely to be supplying milk below standard at the different levels of average solids-not-fat encountered in creamery bulk milk.

It will be seen that at many typical creameries the proportion of producers supplying milk below the standard varies from about 10 per cent in spring and autumn, when the solids-not-fat content of the bulk milk is at its maximum of 8.75-8.80 per cent, to 40 per cent in March and April, with the bulk at 8.50-8.55 per cent. In extreme cases at some creameries this proportion reaches 70 per cent, with the bulks at 8.4 per cent.

Table 1. Incidence of solids-not-fat below the legal standard

Average S.N.F. content for creamery bulk milk	Probable percentage of herds under 8.5 per cent	Average S.N.F. content for creamery bulk milk	Probable percentage of herds under 8.5 per cent
8.85-8.89	6	8.60-8.64	25
8.80-8.84	7	8.55-8.59	36
8.75-8.79	11	8.50-8.54	42
8.70-8.74	13	8.45-8.49	52
8.65-8.69	20	8.40-8.44	64

The table also shows how a very small change in average solids-not-fat (for example, from month to month or district to district), is accompanied by a large change in the proportion of herd samples below standard.

Clearly the problems of milk composition are concerned mainly with the solids-not-fat content, with its decline, and with the seasonal, area, herd and individual cow variations which contribute to the widespread occurrence of genuine milk low in solids-not-fat, and it is intended to deal mostly with these and to limit discussion of the occurrence of low fat.

Factors influencing the Solids-not-Fat Content

For many years the attention of research and advisory workers was directed mainly towards the circumstances affecting the fat content of milk, and less attention was given to those affecting the solids-not-fat. The need for further information was shown by the early work of Cranfield and his colleagues[8] and Nicholson and Lesser[9], who investigated the high incidence of low solids-not-fat on a number of farms, followed by the work of Burr[10] who made an extensive survey of the solids-not-fat content of the individual herd milks delivered throughout 1934 and 1935 at thirty typical creameries in different parts of England and Wales. He found a very wide variation between herds, with 13.1 and 9.2 per cent of the herd samples below the legal standard, the average solids-not-fat content for those years being 8.74 and 8.78 per cent. In two areas he collected details of the farm conditions and from a statistical study of his data observed low solids-not-fat to be correlated with poor feeding and the prevalence of mastitis, a valuable finding which, if not proof of cause and effect, indicated a connection between the standard of herd management and solids-not-fat, and provided encouragement to further study.

A number of investigations of the variations in the solids-not-fat content of milk and of the factors concerned have since been made, and these factors, with emphasis on the new information which has become available, will be considered in turn.

MASTITIS

The effect of mastitis was further explored and it was shown that not only clinical mastitis, but also the very prevalent subclinical streptococcal and staphylococcal forms of the disease, reduce the solids-not-fat content of the milk of the infected quarters.[11]

For a time it was, therefore, thought that mastitis might be a major factor influencing the solids-not-fat in herd milk[12], and this possibility was later definitely investigated by the Chemistry and Bacteriology Departments of the Institute. On the basis of bacteriological and chemical tests of the fore-milk from individual quarters, the cows in a large number of typical commercial herds were classified as " infected " and " not infected, " and analyses were made of the milk of each cow and of two bulk milk samples from each herd, representing the mixed milk from the positive cows and the mixed milk from the negative cows.

The average results were that the bulk milk of the negative cows contained 8.75 per cent, and the bulk milk of the positive cows 8.63 per cent, of solids-not-fat—a difference of 0.12 per cent. If the volume of milk from the positive group is taken as equal to that from the negative group, the average solids-not-fat of the total milk (8.69 per cent) would be 0.06 per cent less than that of the entirely negative comparable group. Actually there were more cows in the negative than in the positive group, and the average decrease in the solids-not-fat percentage of herd milk as a result of mastitis is certainly small—not greater than 0.05 per cent. This is partly due to the fact that in milk from infected quarters marked changes in composition are often confined to the earlier milk drawn, and, of course, to the fact that the milk from positive quarters is mixed with milk from normal quarters.

As regards the decline in solids-not-fat, there are no grounds for suggesting that any increase in mastitis has contributed even to this small extent and, moreover, mastitis reduces the lactose content of milk, the protein content being usually slightly increased, whereas the present deficiency in solids-not-fat is a deficiency of protein.

Although the average effect of mastitis is small, it should be made clear that in occasional herds with an unusually high incidence of severe mastitis—of which much would then be clinical, with some milk of abnormal appearance and unmarketable—there may be a large reduction in the herd solids-not-fat, and this possibility must still be considered in advisory work.

THE ADDITION OF WATER

Surveys of the extent to which the addition of water was responsible for the lowering of solids-not-fat were made between 1938 and 1942, and over 4,000 samples of herd milk were tested for freezing-point on arrival at creameries in different parts of the country. This was made

possible by the use of the rapid modification of the Hortvet freezing-point apparatus designed for the purpose by Temple[13]. The results, which have been reported in full[14], showed that the milk contained an average of about 0.6 per cent of added water, that is, sufficient to lower the solids-not-fat percentage by only 0.05. Some of this will have reached the milk accidentally, but 1 per cent of the herd samples contained 10 per cent or more of extraneous water. The adoption and regular use since then of Temple's apparatus by the larger dairy firms will probably have reduced this small amount of watering.

FEEDING

Until less than ten years ago it was generally held that inadequate feeding of the cow, whilst reducing the yield, did not influence the solids-not-fat content of her milk, but in the meantime it has been clearly demonstrated that under-feeding markedly reduces the solids-not-fat. Thus the plane of nutrition of the cow is of great importance. During the investigation of the increased occurrence of low solids-not-fat during the early months of 1942 and 1943[15], inquiries showed that on many farms the herds were poorly fed under the war-time conditions of a much reduced supply of concentrates and the need for increased reliance on home-grown feedingstuffs. In view of this, and the unusually large increase in solids-not-fat content that occurred when the herds were turned out to spring grass, it seemed likely that the low winter levels (due mainly to a low protein content of the milk) were caused by inadequate feeding. This possibility was in line with Burr's earlier correlation and was strongly supported by a then recent report from New Zealand[16] describing a well-controlled experiment in which halving the production ration of a group of cows reduced the solids-not-fat content of their milk.

It was decided to find out by direct experiment the effect of known deficiencies of energy and of protein in the ration on the composition of the milk. This was done during the winter of 1944-5[3]. Eighteen Shorthorn cows in the Institute's herd were divided into three groups of six and the following three types of ration were given, one to each group according to a Latin square design : (1) a normal ration providing all the energy (starch equivalent) and protein (protein equivalent) required by modern feeding standards for both maintenance and production, (2) a ration providing all the energy but only 60 per cent of the protein, and (3) a ration providing all the protein but only 75 per cent of the energy. Each group of cows after five weeks on one ration was changed over to another, and after a further five weeks to a third, so that during the experiment each cow received each ration for five weeks. Detailed chemical analyses of the milk of each cow were made regularly, and the average results for the last two weeks on each ration are given in Table 2.

Both the low protein ration and the low energy ration quickly and appreciably reduced the solids-not-fat percentage, but the low energy ration had the more drastic effect. There was no effect on the fat content of the milk.

Table 2. Effect of Underfeeding on the Composition of Milk

Ration of Cows	Fat *per cent*	Solids-not-fat *per cent*	Protein *per cent*	Lactose *per cent*
Normal	3.76	8.68	3.07	4.71
Protein equivalent 60% of normal	3.71	8.50	2.95	4.65
Starch equivalent 75% of normal	3.76	8.34	2.86	4.61

It will be seen that the low protein ration reduced the average solids-not-fat content by 0.18 per cent down to 8.50 per cent, and the low energy ration by 0.34 per cent down to 8.34 per cent—well below the legal standard—and statistically these differences were highly significant. It is interesting that in both cases about two-thirds of the fall in solids-not-fat was in the protein content and only one-third in the lactose content. Thus were reproduced under experimental conditions the low levels of winter solids-not-fat and the same changes in detailed composition as had been observed in field work.

This effect of underfeeding has been confirmed in subsequent experiments including one in which it was found that when two rations differed only in the quality of the hay used for the maintenance ration, one being classed as of moderate and the other of poor quality, the production rations being identical, milk of lower solids-not-fat content was produced on the poor hay.

Following this work on levels of feeding, the rapid rise in the solids-not-fat content of milk which occurs when cows are turned on to young grass in the spring was investigated. This rise is commonly between 0.2 and 0.4 per cent but may be up to 0.6 or 0.7 per cent if the solids-not-fat content was very low in late winter owing to underfeeding. Increase in the milk protein content accounts for about four-fifths of these changes.

Attempts were made to simulate this effect of spring grass by liberal supplements of carbohydrate, protein or carotene to the ordinary late winter rations, but without success ; although freshly-cut grass given to cows kept inside reproduced the usual grazing response. The reason for this stimulating effect of young grass is not yet known, but the possibility that it may be due to oestrogenic hormones which have recently been shown to be present in English grasses and clover[17] is being studied. It was observed some years ago[18,19] that the administration of oestrogens (ovarian hormones) to lactating cows increased the solids-not-fat content of their milk.

If the stimulating property were understood and were conserved in grass products for use in the winter, it might greatly benefit the winter levels of solids-not-fat.

BREED AND BREEDING

It is only within the last three years that reliable data for the solids-not-fat content of the milk of the main breeds of the dairy cow under modern conditions have become available. The detailed composition of the milk of a representative selection of herds of the Ayrshire, Friesian, Guernsey and Shorthorn breeds was investigated at the Institute throughout the year 1948[20]. The average fat and solids-not-fat results are given in Table 3, along with the average results given by Provan[7] for bulk herd milk of these breeds for the two years October, 1945 to September 1947, and relating to milk delivered to Milk Marketing Board creameries. It will be seen that the two sets of solids-not-fat values are in remarkably close agreement.

Table 3. Composition of Milk of Different Breeds

Breed	N.I.R.D. 1948		M.M.B. 1945-47	
	Butter-fat *per cent*	Solids-not-fat *per cent*	Butter-fat *per cent*	Solids-not-fat *per cent*
Guernsey	4.55	9.01	4.41*	8.93*
Ayrshire	3.72	8.78	3.72	8.73
Shorthorn	3.56	8.71	3.65	8.68
Friesian	3.49	8.59	3.45	8.58

*Jersey and Guernsey milk.

Comparison of these values with the variable and, in part, unrepresentative ones reported in the earlier years of the century shows that the breeds are placed in the same order as formerly and that, with the possible exception of the Friesian, where the wide variation in the early data makes it difficult to judge, the solids-not-fat content for each breed has appreciably declined. The present difference of only 0.10-0.12 per cent solids-not-fat between the Shorthorn and Friesian breeds may appear of little significance, but when the herd-to-herd and seasonal variations around their averages are considered, it will be evident that the lower Friesian figure brings a much larger number of genuine milks below the standard of 8.5 per cent. It should be emphasized that these are average values for each breed and that there is a wide variation in solids-not-fat content, as in fat content and milk yield, between individual animals and between herds within each breed. The strain or family is extremely important, and there are strains which successfully combine high yield with good solids-not-fat content for the breed.

STAGE OF LACTATION

There is no recent additional information regarding the effect of the stage of lactation of the cow, but it is mentioned as it must be considered when judging the solids-not-fat content of the milk of the herd or individual cows. The solids-not-fat content is high for the first two or three weeks of a lactation and then falls for about a month to a

minimum level which normally persists until about the fifth month of pregnancy, when it rises steadily until drying-off is started. Cows not in calf show a fall in solids-not-fat throughout the lactation and if this is prolonged very poor milk is produced. These effects will influence the solids-not-fat of the herd milk if calving takes place mainly at one season of the year or if there is a high proportion of stale cows.

Discussion of the Problems of Solids-not-Fat

There are, it is clear, two dominant factors which influence the solids-not-fat content of milk—the genetic and the nutritional. Breeding sets the potential upper limit of solids-not-fat, as it does of fat, that can be achieved under the best conditions of management, whilst of the other factors that can be controlled it is the plane of nutrition which determines the level that is actually attained. Both factors need further study; for example, not sufficient is known of their relative importance as a cause of low solids-not-fat at the present time, but their significance regarding the problems of solids-not-fat can be approximately assessed at this stage.

Evidence that the production of milk poor in solids-not-fat by any given animal is of genetic origin must, of necessity, be largely circumstantial, for the past records of solids-not-fat on which a direct judgment could be based do not exist. Nevertheless, accumulated experience has shown that the unsatisfactory solids-not-fat content of the milk of an unduly high and disturbing number of our pure-bred and cross-bred cows, and of the herds in which they are present to widely varying extents, is due to their genetic deficiency. When these herds are well managed and fed, their milk shows the usual variations from month to month but at a low average level, and there is little or no response to a higher plane of nutrition or to extra mineral supplements. Even on good spring pasture the solids-not-fat level reached is below normal. In advisory work, past creamery records of the herd solids-not-fat, if available for a year or more, are a great help in deciding whether the low level is of this type or has recently arisen from some other cause.

In addition to being important as a frequent sole cause of low solids-not-fat, hereditary deficiency when less marked plays a big part coupled with other factors, e.g., it allows a relatively small nutritional deficiency the more readily to bring the solids-not-fat level to below standard, and it is difficult to elucidate the many puzzling cases of low-solids-not-fat that arise in this way.

This serious position has resulted from, and is being aggravated by, a policy of breeding for higher milk yields, without the essential attention to the composition of the milk. Whereas some attention has been paid to fat content, there has been virtually none to the solids-not-fat and, as is well known, higher yields tend to be associated naturally with poorer composition. The decline in the average solids-

not-fat content of milk over the years is partly attributable to an increase in the proportion of genetically poor cows within most, if not all, the main dairy breeds.

The rapid change in the proportions in which these different breeds are present in the national dairy herd has also contributed to the decline, as there has been a considerable replacement of the formerly predominant Shorthorn by Friesian and cross-bred Friesian stock. In the annual report of the Production Division of the Milk Marketing Board for 1949-50 it is estimated that the percentage make-up of Britain's national herd is now : Shorthorn type 34, Friesian type 32, Ayrshire type 11, Channel Island cattle 9, and other breeds 14. These figures are closely in line with the bull licensing figures for last year, with Friesian 28.6, Shorthorn 28.3, and Ayrshire 10.1 per cent, and with the present breed demands for artificial insemination, but contrast sharply with the bull licensing figures for fifteen years ago of Friesian 6.6, Shorthorn 65.0, and Ayrshire 1.2 per cent. As the average solids-not-fat content for the Friesian breed is lower than that for the other breeds, these changes, made with the valuable object of increasing milk yields, will have reduced the average composition of our milk supplies, and the full effect of this has not yet been felt.

There is no reason for believing that the decline in solids-not-fat prior to 1940 was assisted by any deterioration in the nutritional status of the herds, as during these years imported concentrates were cheap and freely used and herds were, on the whole, as well fed as at any time. The further fall in solids-not-fat during the winter months of the early war years was, on the other hand, due largely to the sudden shortage of feedingstuffs.

The study of the role of adequate winter rations and of good grazing in maintaining a satisfactory solids-not-fat content has led to a fuller understanding of the seasonal variations in solids-not-fat. It is also realized that the general standard of management of the farm is reflected in the solids-not-fat content of the milk produced, through its influence on the quantity and the nutritional quality of all the home-grown crops available for the dairy herd.

The solids-not-fat content is highest when the herd is on grazing of high nutritive value in spring and autumn, the influx of fresh calvers also contributing to the autumn peak, and the decrease in solids-not-fat in July and August is most marked in dry weather when herbage is scarce and of low nutritive value.

In winter it is difficult to prevent some fall in solids-not-fat, and even when feeding is in accordance with the normal standards, there is a tendency for the long November to April period of winter feeding to show a cumulative effect. The increase in autumn calving may play a part here, as for the majority of animals this period coincides with their stage of greatest yield, which is also the stage of lowest solids-not-fat in the lactation. Trials have shown, however, that a really generous plane of nutrition throughout this period delays the onset and reduces the eventual extent of the fall, with a correspondingly

small rise on spring pasture. A low plane of nutrition during the winter, owing to a deficiency of energy or protein, and arising from a shortage of bulky foods or of home-grown or purchased concentrates, markedly reduces the solids-not-fat content, and often to below the legal standard. If the deficiency in feeding has been prolonged, the return to normal rations in late winter, whilst improving the milk yield, brings only a slight improvement in the solids-not-fat content, but this will later respond to grazing.

As was stated earlier, low solids-not-fat in winter occurs most frequently on farms in the western areas, and this is also explicable, at least in part, on nutritional grounds. These are areas of high rainfall, well suited to grass production and dairying, but harvesting is often made difficult by the wet conditions which cause a loss in nutritive value, and in some years an actual shortage, of the hay on which the winter feeding is largely based. Routine creamery solids-not-fat records for these parts show that a poor hay harvest, due to adverse conditions, as, for example, in 1946 and 1950, is followed by unusually low solids-not-fat contents the following winter. By contrast with the west, in eastern districts the summer rainfall is lower and hay harvests are normally good, but pasture is scarcer in the late summer months when the minimum solids-not-fat occurs.

The plane of nutrition of the cow clearly influences the solids-not-fat content of milk at all times of the year, but further research is required on this and the other factors which may be involved in the seasonal trends of solids-not-fat, particularly in the autumn to late winter fall. There is no doubt, however, that in many areas improvement in winter feeding would reduce the incidence of very low solids-not-fat and that this, coupled with adequate supplementary feeding as required in late summer, would raise the general yearly level of composition. Thus the advantage of a high standard of management of crops and stock is abundantly demonstrated. Sufficient quantities of home-grown foods of high nutritive value should be produced—grass, hay, artificially dried grass, silage, other fodders, cereals, etc.—to ensure that, when these are used with such amounts of concentrates as it is intended to purchase, cows will calve in good condition and receive balanced rations conforming to the accepted feeding standards throughout their lactation, especially during the often difficult winter and late summer months.

The Occurrence of Low Butter Fat

The cases of low butterfat content encountered in advisory work range from those where the fat content of the milk of the individual cow or herd is slightly lower than is to be expected, to those of considerable and sometimes prolonged depression of fat (in some instances down to less than 2 per cent in herd milk) which render the milk unmarketable. Many of the cases can be dealt with in terms of the already well-known facts which influence fat content, and these need not be considered here. The prime importance, again in this connection, of the breed and strain of cow should, however, be stressed,

and the following latest data on the average fat content of the milk of the different breeds taken from the report of National Milk Records for the year 1949-50 will be of interest: Jersey 5.02, Guernsey 4.53, South Devon 4.23, Ayrshire 3.80, Red Poll 3.59, Shorthorn 3.57, and Friesian 3.45 per cent.

The causes of other cases of low fat, including those of extreme deficiency, have until recently remained obscure but much light has now been thrown on them by work showing that the proportion of roughage, or fibre, in the cow's diet is another important factor to be considered. For many years the view was held that changes in the amount or nature of the food of the cow, provided that she was reasonably well nourished, would not cause any change, or at the most a very small and temporary one, in the fat content of her milk. The known exceptions were the change from stall-feeding to spring pasture, when there might be a moderate, temporary fall in fat content accompanying a large flush in milk yield, the actual weight of fat secreted being unchanged or increased, and the feeding of excessive amounts of unsaturated oils, including cod liver oil. But work carried out, mostly within the last five years, in America, Australia, and in this country has shown that too low an intake of roughage—that is a low roughage-high concentrate diet—may seriously reduce the fat content, and this can occur during both the grazing and stall-feeding regimes. McClymont[21] has recently reviewed the earlier work and given an account of his Australian experiences.

GRAZING

Under grazing conditions this trouble may arise on the change from winter feeding, with herds permitted unrestricted grazing on young spring pasture of low fibre and high protein content, and given at the same time liberal, or definitely excessive, amounts of supplementary concentrates. In spite of the increased milk yield, the total weight of fat secreted is often drastically reduced. This phenomenon is well illustrated by the following typical results[20] obtained towards the end of April, 1949, for the milk of a herd of fifty-five Shorthorn cows that had been producing milk low in fat for some weeks whilst grazing a young ryegrass-clover ley: evening milk (70 gallons), 2.63 per cent; morning milk (100 gallons), 1.93 per cent. It is noteworthy that the corresponding solids-not-fat contents were over 9.1 per cent. Individual cow tests for the same milkings gave many results below 1.5 per cent fat in the morning (a few were below 1.0 per cent) and below 2.0 per cent in the evening. Twenty-four of the higher yielding cows averaging 1.54 and 1.96 per cent fat in their morning and evening milks were allocated to two experimental groups. The provision of 6 lb. of hay per cow daily to one group rapidly increased the fat content of its milk to nearly normal levels, whereas the milk of the untreated group remained unchanged. Both groups were then transferred to a more mature pasture and, although no hay was given, the fat contents rapidly became normal. This illustrated the difference as regards fat production that may exist between fields on the same farm.

This type of fat depression is apparently becoming more frequent, and this may possibly be related to the increasing use of leys for the dairy herd and the improvements in pasture management giving leafy swards of low fibre content ; but further study is certainly needed of the particular predisposing conditions of management of both pasture and stock. The steps to be taken to prevent these low fats include control of the grazing, the feeding of a few pounds of hay or possibly straw per cow daily if necessary, and the avoidance of excessive use of concentrates. Quick recovery from an existing low level of fat is usually obtained, without a drop in milk yield, by the same measures.

Winter Feeding

Unusually small quantities of roughage (that is, of hay, good quality straw or silage), together with heavy feeding or over-feeding of concentrates, have also accounted for the low, and at times extremely low, fats occurring on some farms during the winter months, and the remedy here is balanced rations including adequate roughage. The Feeding and Metabolism Department and the Chemistry Department of the Institute are investigating, from the practical and the fundamental metabolic aspects, the effect of winter diets low in roughage and high in concentrates ; little is known about either of these, and a series of experiments is in progress. In the first of these [22], carried out in the winter of 1949-50, three groups of four Shorthorn cows were used to compare a control ration of 18 lb. of hay and 30 lb. of mangolds per cow daily and balanced concentrates according to milk yield, with rations in which hay was reduced to 6 lb. and 2 lb. respectively, extra concentrates, largely carbohydrate, being given to compensate. These rations were fed, one to each group, for a treatment period of four weeks. This was preceded by a period of three weeks, and followed by one of four weeks, when the control ration was given to all groups. For the pre-treatment period the average fat content of the milk was 3.83, 3.81, and 3.78 per cent in the groups which subsequently received 18, 6 and 2 lb. of hay respectively. The low roughage rations significantly reduced the fat content ; the average for the 6 lb. group was 3.28 per cent for the third and fourth weeks, and for the 2 lb. group 3.17 per cent. When the control ration was restored the fat content steadily recovered, and for the third and fourth weeks of the post-treatment period averaged 3.80, 3.80 and 3.76 per cent in the three groups. The changes of ration did not affect the solids-not-fat content of the milk.

In the subsequent experiments not yet completed, different kinds and proportions of roughage and amounts and kinds of concentrate mixture are being used and much greater depressions of fat have been observed.

Improvement of Compositional Quality

Finally, the measures that may be taken to arrest further decline in, and to improve, as quickly as possible, the composition and hence the nutritive value of our milk supplies are outlined. The present difficulties with solids-not-fat below the legal standard should certainly

not be met, as is sometimes seriously suggested, by a lowering of the standard—adopted fifty years ago—as if this were done, further deterioration would in due course follow.

Breeding Policy

The selection of breeding stock should be carried out with attention not only to the fat but also to the solids-not-fat content of the milk. There is a positive correlation between the fat and solids-not-fat contents of milk, as is shown by the averages for the various breeds, and although this applies in the strict statistical sense to the milks of single herds and animals, the range of solids-not-fat percentage that then accompanies any given level of fat is so wide, especially for individual cows, that the fat percentage is of little or no value as a guide to the solids-not-fat percentage and would frequently be misleading. Some cows combine high fat with low solids-not-fat and vice versa. Although breeding for higher fat would bring a small and slow overall improvement in all solids-not-fat, there would be many disappointing exceptions. The very small amount of information as yet available on the inheritance of solids-not-fat shows that fat and solids-not-fat are separately inherited characteristics, and for real progress to be made with solids-not-fat it should, like yield and fat, be separately considered. For this purpose the testing of milk of individual cows for solids-not-fat is essential, and the extension in due course of National Milk Records to include solids-not-fat testing for those breeders who desire it is suggested.

Management and Feeding

A high standard of management of crops and stock should be maintained, owing to the influence of the plane of nutrition and health of the herd on the composition of its milk. There should be sufficient home-grown foods of high quality to ensure, with the purchased concentrates, adequate and balanced rations throughout the year. In this way the solids-not-fat content of the milk will reach its best level and also the fat content, provided care is taken to include a sufficient proportion of roughage in the diet.

Payment on the Basis of Composition

At present a bonus may be paid for milk with a minimum of 4 per cent fat from Channel Island and South Devon cows, and there has been much discussion recently of the feasibility and advantages of instituting a national scheme of payment for all milk according to its compositional quality. There is no doubt that a well-chosen price differentiation would be an equitable form of payment reflecting the relative costs of production, and that such a scheme, based initially possibly on the fat percentage alone and later, as experience is gained, on the fat and solids-not-fat, by providing a financial incentive would be the most effective means of encouraging the producer to carry out his breeding policy and herd management with due regard to milk composition.

ADVISORY WORK

In this improvement of compositional quality the advisory officer has an important role—in developing the interest of the producer in the subject, in ensuring that he fully understands the circumstances which influence milk composition, and in helping him in their application to his particular case.

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The compositional quality of milk has also been discussed recently in the following articles :

A. L. PROVAN, *J. Brit. Dairy Fmrs' Ass.*, 1950, **54,** 38.
S. BARTLETT and H. D. KAY, *J. Agric. Soc.*, 1950, **111,** 87.

ABSTRACTS

ANIMAL BREEDING

The Genetic History and Breed Structure of British Friesian Cattle. A. Robertson and A. A. Asker. *Emp. J. exp. Agric.*, 1951, **19**, 113-30.

A brief history of British Friesian Cattle in this country is given. The work is confined to the pedigrees of registered females so that a truer picture of the breed structure is obtained.

Some interesting material is presented and the following points are of major interest. The percentage contribution which the foundation stock and the various importations have made to the breed are estimated in 1945 to be : foundation stock 17.2 per cent, 1914 importation 40.6 per cent, 1922 importation 17.9 per cent, 1936 importation 24.3 per cent, grading up 0.4 per cent. It is suggested that it takes 15 years to get the full influence of any importation and, as such, the 1936 importation had not in 1945 reached its maximum effect, which is likely to be about 35 per cent.

In the purchase of the 1936 importation particular attention was paid to butterfat percentage. It would seem from the available data that the fat-percentage has risen in the breed from 3.28 per cent in 1934-37 to 3.44 per cent in 1948-49, and almost all of this improvement is genetic in origin.

The two individual bulls which have had most influence on the breed are Ceres 4497 and his double grandsire Albert 1306. Both were used before 1910 and neither of them left Holland. They are followed by Terling (Imp) Marthus and Hedges Second Series.

The structure of the breed consists of 20-30 top level herds which sell bulls to a middle group consisting of 100-200 herds ; a bottom group of about 1800 herds get their bulls mainly from the middle group and sell their bulls to the non-pedigree herds of Friesian type. Because of their success in selling bulls, the top level herds are all the time losing their genetic superiority while the lower level are being continually raised ; it is considered that the genetic difference in yield between the top and bottom groups is probably less than 100 gallons per cow per year.

The 1936 importation has undoubtedly increased the butterfat percentage and this may be continued by the recent importation though rather more slowly as the genetic level for fat percentage reaches that of Holland. From the breeding point further importations seem unfortunate as " a breeder has little incentive to improve his herd genetically by the necessarily laborious method of progeny-testing. He must realize that the simplest way to establish a fashionable bull-selling herd is to buy himself a bull out of the next importation ".

The importance of the new importation to the breed will depend largely on its effect on the top group of herds, and the effect of the imported sires in A.I. The latter might, in a generation or two, raise the non-pedigree herds until they are genetically superior to the general mass of pedigree herds.

W. L.

ANIMAL NUTRITION

Starch Equivalents of Herbage Products

In the early days of quantitative work in animal nutrition it was believed that there was a close relationship between the indigestible portion of a feedingstuff and the percentage of crude fibre, the latter being a residue of indefinite composition obtained by following a rigid analytical routine. Later, ideas altered and " lignin " was considered to be more closely related to indigestibility. But " lignin " was not much nearer to being a definite entity and was obtained merely by following a different, and by no means easier, technique. In view of this, and in view of the huge mass of crude fibre data which had been accumulated during the years, lignin estimations never became the fashion.

It is therefore interesting to note that quite recent studies tend to confirm that crude fibre has a real significance in regard to indigestibility, and one of these, by Hallsworth[1], has involved statistical analyses of hundreds of results obtained by different authors using a wide variety of feeding-stuffs on cattle, sheep, horses, pigs and poultry. The effect of fibre in reducing digestibility was greatest with pigs and poultry, less with horses, and still less with cattle and sheep ; there was no significant difference between the effects in cattle and in sheep. The results found for herbage products (grass, lucerne, hay, silage, etc.) were of special interest because they were used to obtain an equation whereby the starch equivalents of these feeding-stuffs (on the basis of dry matter content) could be estimated from the crude fibre percentage of the dry matter.

Previously it had been customary to estimate S.E. from the crude protein percentage, and indeed a high positive correlation between these was found ; but the correlation values for pasture grass and lucerne were different, and it was suspected that the reason lay in the higher fibre content of the latter. When the basis of the calculation was altered from protein to fibre, a very high negative correlation between fibre and S.E. was obtained, and it was practically the same for both grass and lucerne. It would seem that the negative correlation associated with fibre is the fundamental one, and that the positive correlation with protein is due merely to the fact that herbage high in fibre is low in protein, and vice versa. The equation found is as follows :

$$\text{Starch Equivalent (of the dry matter)} = 95.11 - 1.6633y$$
$$(\text{where } y = \%\text{ of crude fibre in the dry matter})$$

and Hallsworth suggests that this relationship may be of use when it is desired to relate pasture competition to growth rates, liveweight gains, or milk production of grazing stock.

A warning against the too facile acceptance of " standards " in nutrition is given, however, by Blaxter [2] in a searching review of these. He points out that the utilization of a feeding-stuff, and hence its starch equivalent, is governed by many factors, including the plane of nutrition of the animal, the admixture with other feeding-stuffs, the palatibility of the food (affecting appetite and digestion), and management factors, apart from the idiosyncrasies of the animals themselves. Variations up to 25 per cent have been found in the estimations made for the same feeding-stuff on different occasions ! In view of all this, Blaxter points out that " standards " are useless for rationing the individual animal, and, if applied to a herd too rigidly, some animals will be underfed and others overfed. Their main use in his opinion is to afford a measure where the purchase of foods may be regulated and to assist in the cropping of a farm, whereby the home-grown crops can be anticipated to provide a certain amount of total starch equivalent which can then be apportioned to the animals according to their individual needs as evidenced by body condition and milking capacity.

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S. M. B.

DAIRY HUSBANDRY

Dairy Cattle Improvement

In most of the major milk-producing countries of the world there has been an increasing interest in milk recording and butterfat testing during the post-war years. In many there has been a concomitant development in artificial insemination and in some, greater efforts have been made to progeny-test dairy bulls and to make greater use of those which are found to produce daughters of a higher level of output than their dams. The integration of these various developments and detailed study of their effects is clearly of very great importance. In England and Wales the Milk Marketing Board is responsible for the administration of National Milk Records, the Bureau of Records and much of the artificial insemination. This makes possible a balanced development of these services and a careful study of their influence on the progress of dairy farming. The recent publication of the first report of the Production Division of the Milk Marketing Board is therefore of great interest to all who are concerned with milk production. (*Milk Marketing Board. Report of the Production Division* No. 1, 1950.)

Apart from the basic information on the development of the dairy industry, and on National Milk Records and the Board's Artificial Insemination Centres, the results of the Bureau of Records' investigations

throw light on several aspects of milk production that have received little attention since the original work of Sanders (SANDERS, H. G. *J. Agric. Sci.*, 1927, **17**, 3). Reliable mean lactation curves for heifers and for cows calving in October and March are given. The mean lactation yields for cows calving each month of the year in this particular survey bear out the findings of previous investigations and show that the cows calving in the period October to January tend to produce the higher yield and those calving June to August the lower yield. Included in these investigations is a summary by breeds of production of heifers in their first and second lactation, classified according to age at first calving. In most breeds the heifers calving for the first time at two years old produced about as much in their second lactation (beginning on average when they were a little over three years old) as the heifers in their first lactation which calved for the first time at three years old. The lactation commencing at two years was apparently carried through without prejudice to the lactation beginning at three years old. Only by extended study over subsequent lactations can an accurate appraisal of the total effect on production be obtained, but these data already suggest that more trials of earlier calvings might be made, especially in the larger dairy breeds.

An interesting description of the progress of the dairying industry in New Zealand is published each year by the New Zealand Dairy Board. In the current report (*New Zealand Dairy Board*, 1950, 26*th Annual Report*, Year Ended July 31, 1950) apart from information on the development of milk recording, butterfat testing and artificial insemination, reports on investigation of certain dairy farm practices are included. In New Zealand, where grass often forms a very high proportion of the milking cow's diet, high yields of milk and butterfat per acre are often obtained. These sometimes exceed 250 lb., and occasionally 300 lb. of butterfat, per acre. An effort has been made to correlate these high yields with particular practices. It was found, however, that definition of the best combination of farm practices to promote high production per acre was difficult owing to the very great influence of that indefinable factor—the farmer himself. The report also contains data on rate of milking, production of cattle bred by artificial insemination and on the effect of twinning on the level of production.

In the United States of America, control of official recording and butter-fat testing of pure-bred cattle is in the hands of the breed societies and a considerable amount of the investigational work is carried out by state experiment stations. There is therefore no report on the development of milk production strictly comparable with those mentioned above for England and Wales and New Zealand. A report (*Report of the Chief of the Bureau of Dairy Industry*, Agricultural Research Administration, 1949), published from the Bureau of Dairy Industry each year, gives a summary of the work of the Dairy Herd Improvement Association and also includes a brief decription of the work of federal research teams concerned with dairy cattle and dairy farming improvement. Although the proportion of cows recorded and tested in the United States is lower

than in England and Wales, there are now about one million cows included in the Dairy Herd Improvement Association and the numbers are increasing rapidly. The Bureau has compiled dam-daughter production comparisons for over 27,000 bulls used in Dairy Herd Improvement Associations.

A. S. F.

POULTRY HUSBANDRY

Egg Quality

Recently the need to supply first-class shell eggs for storage or other purposes where the eggs are retained over a period, has brought under scrutiny once more the value of candling in testing eggs for quality. Reference is made to the limitations of candling in a paper on " A Study of Egg Quality on the Farm " by Stadelman and Jensen (*Poul. Sci.*, 1951, **30**, 367-71). Although the paper deals primarily with changes in quality during collection and distribution, the authors attribute some anomalies to candling. An increase in blood and meat spots reported after eggs had been held seven days suggested that these defects are easier to detect as eggs become older. The authors also refer to their findings on a candling basis with regard to general quality deterioration over the same period. On a candling basis there was little change in the total number of eggs graded as first quality and super quality after a lapse of seven days, although the number of super quality had declined and the number of first quality consequently increased. Nevertheless, over the same period the albumen index of the broken out eggs showed a substantial decline—of the order of 30 per cent. The authors point out that humidity of the store room appeared of major importance in maintaining the grade on a candling basis, but the temperature was the chief factor influencing quality on the basis of the albumen index. Furthermore, while temperature was of some importance in influencing grading on a candling basis, humidity had little or no effect on loss of albumen index. These surprising conclusions confirm the need to find a more suitable method than candling for testing eggs for quality.

Another recent publication which deals at length with egg quality is " The Production and Marketing of Eggs " (*Bulletin No.* 307 of the *Dept. of Agriculture, South Africa*) by Professor A. M. M. Gericke. This is a comprehensive account of testing eggs for quality, and it discusses methods calculated to ensure, as far as possible, the avoidance of the more common quality defects.

A recently reported cause of poor quality in eggshells is the subject of a paper by Tyler in the *Brit. J. Nutrit.*, 1950, **4**, 112-28 in an article entitled " The Effects of Sulphanilamide on the Metabolism of Calcium, Carbonate, Phosphorus, Chloride and Nitrogen in the Laying Hen ". Tyler demonstrates that the administration of sulphanilamide depresses the retention of calcium and carbonate and leads to the production of thin-shelled eggs. Although the shells regained normal thickness on the withdrawal of the drug from the diet, the calcium retention remained low and gave rise to an adverse calcium balance.

Management

Halbrook, Winter and Sutton give an account of " The Microflora of Poultry House Litter and Droppings " in *Poult. Sci.*, 1951, **30**, 381-8. They state that built-up litter over one year old contains fewer yeasts, moulds and coliforms than litter changed at eight weeks or more frequently, while liming built-up litter reduced all classes of bacteria, yeasts and moulds. The authors also consider that food and water are major factors influencing the microflora of the intestinal tract of chickens. On another aspect of poultry management Schoenleber and Campbell in the same Journal (*Ibid*, 409-16) review the results achieved with hens exposed to ultraviolet radiation. They found that over a period of five years hens receiving exposure to a bactericidal ultraviolet light laid between 10 per cent to 19 per cent more eggs than the control group. The latter were housed in a similar house from which daylight was excluded, but they received ordinary artificial light. All birds received sufficient dietary vitamin D. The mortality rate in both groups was comparable and no case was traced to bacterial infection. The authors believe that the improved egg production can be traced to the effect of stimulation induced by rays of about 2537 angstrom units.

" The Effect of Rapidity of Hatching on Growth, Egg Production, Mortality and Sex Ratios in the Domestic Hen " is discussed by Williams, Godfrey and Thompson in *Poult. Sci.*, 1951, **30**, 599-606. The authors state that early hatching chicks grew slightly faster than late emerging chicks if they were removed and given food and water. Early hatching pullet chicks matured slightly earlier and laid rather more eggs than the later hatching pullets. The authors doubt, however, whether this segregation is economically justified. There was no relation between early hatching and laying mortality. Egg weight and early and late hatching were closely correlated ; the larger the egg the longer the time required for it to hatch.

Nutrition

The number of papers dealing with factors in the A.P.F. group other than B_{12} continue to increase. One interesting paper by Lassen, Bacon and Dunn (*Poult. Sci.*, 1951, **30**, 422-5) gives an account of " An Evaluation of Condensed Whale Solubles as a Supplement in Poultry Nutrition ". The authors present data to show that with growing chicks, in which the carbohydrate is mainly supplied by maize and soya bean meal, condensed whale solubles appeared as effective in stimulating growth as sardine solubles or commercial A.P.F. supplements. The B_{12} content of both the commercial preparations and the sardine solubles was appreciably higher than that of the C.W.S. It must therefore be concluded that other factors in the C.W.S. stimulated growth. Much the same conclusions are reached in a paper by Heuser and Norris (*Ibid*, 470-1) on " An Unknown Nutritive Factor in Feeds of Animal Origin ". The authors show that various A.P.F. supplements stimulated greater growth than B_{12} alone.

R. C.

VEGETABLE CROPS

Research into Irrigation. Anon. *The Grower*, 1951, **35**, 1205-6, 1359-61, 1273-4, **36**, 32-3.

This series of articles is a review of commercial irrigation practice.

The author states that field capacity (the quantity of water retained after thorough wetting and normal drainage) may be 10 per cent by weight in sandy loams, or over 30 per cent in heavier soils.

When water is applied to the soil, the surface layers are first saturated and the depth of the saturated layer then gradually increases. Plants can absorb most of the water within reach of their roots, but when the soil moisture content reaches a critical low value (the permanent wilting point) the roots can no longer take it up. This value varies from 5 per cent in sandy loam to 20 per cent in fine clay.

The difference between field capacity and permanent wilting point is a measure of the capacity of the soil to store available water.

The soil normally loses water by drainage, surface drying and by the transpiration of the vegetation growing upon it. Poor soil structure as a result of bad cultivation or lack of organic matter, may cause wastage by run-off during a shower. Removal of excess water by deep drainage is not wasteful because the soil has reached field capacity before the drains start to flow. The soil type and condition determine the amount of available water which it will store and also the rate at which it can absorb water falling upon it.

It is unnecessary to apply water in excess of the amount required to saturate the soil to the greatest depth reached by the roots of the particular crop. Application of insufficient water is, however, bad because it encourages root growth in the surface layers which are more liable to drought conditions.

Plants can obtain water readily from the soil until the permanent wilting point is reached. It is therefore not necessary to irrigate until the soil moisture content nears permanent wilting point. In general it does the plants no harm to be short of water for a day or so, but it is advisable not to wait for the crop to wilt before irrigating.

Temporary wilting may occur during periods of wind and sun when the roots cannot take up water quickly enough to replace heavy losses by transpiration. When these conditions cease, the plant becomes turgid again.

The articles include a graph showing the amount of water required to wet various soil types to different depths.

The author discusses various sources of irrigation water supply, machinery, methods, and rates of application of water on soils of various types.

A Practical Soil Moisture Meter as a Scientific Guide to Irrigation Practices. G. J. Bouyoucos. *Agronomy J.*, 1950, **42**, 104-7.

The author describes his soil moisture gauge which is under commercial production in America. The meter consists of a portable A.C. impedance bridge powered by dry batteries and is calibrated directly in percentage of available moisture in the soil. The buried element consists of two electrodes embedded in a plaster of paris or nylon-wound block.

The meter can be used in most soil types, but the readings may be somewhat high in peats, pure sands and very saline soils. Full instructions are given for placing the blocks in the soil and for operating the meter.

Electrical Soil Measurements. F. A. Evans and J. G. G. Hempson. *The Grower*, 1951, **38**, 367.

The authors describe a simple modification of Bouyoucos' conductivity method of estimating the moisture content of the soil. They have found that for ordinary irrigation purposes, a very simple resistance bridge is adequate and the high accuracy of the orthodox AC bridge is unnecessary and, indeed, undesirable owing to inherent small differences between individual blocks.

The soil in any field is far from homogenous and in order to allow for parts being drier than any of the places where blocks are actually buried, it is desirable to irrigate when readings indicate that 20 per cent of the available moisture still remains.

Evans and Hempson have tried other materials for making blocks but these usually have unfavourable effects on consistency of performance. Various American workers have used nylon, glass fibre and other materials in place of plaster of paris. Some of these appear to be more suitable for research work. For every-day control of irrigation, however, the plaster of paris blocks are adequate.

Dr. Pereira of Kenya Department of Agriculture, uses a metallic gauze screen around the block to prevent conductivity of the soil outside modifying the resistance between the electrodes inside.

Plaster of Paris Blocks for Soil Moisture Measurement. J. S. Wolfe. *The Grower*, 1951, **36**, 423-5.

Full instructions are given in this article for making the plaster of paris resistance blocks referred to in the previous abstract together with a wiring diagram for a simple A.C. bridge resistance meter, which can be made up by anyone versed in radio work, at a cost of about £5.

Opinions differ as to the critical soil moisture content at which irrigation becomes necessary. The apparatus must, therefore, be calibrated to indicate between the limits of field capacity and wilting point for the particular soil.

E. J. W.

NUTRITUTION OF HORTICULTURAL CROPS

Biochemical Aspects of Plant Nutrition

All problems of plant nutrition are indirectly related to the biochemistry of the plant. Research in plant nutrition now lays as much emphasis on the function of minerals in plants as proving the necessity of an element for optimal plant growth.

The observable changes in plant metabolism brought about by deficiencies or toxicities of minerals is not only important in arriving at dietetic conclusions about foodstuffs, but also allows the specialist advisory officer to diagnose nutritional disorders with more certainty than would otherwise have been the case.

Mineral Nutrition in Relation to the Biochemistry and Physiology of Potatoes. E. G. MULDER. *Plant and Soil*, 1949, **2**, 59-121.

Potatoes grown in a potash deficient soil are subject to blackening, even before cooking, when cut open and exposed to the air. This is due, apparently, to the presence in large quantities of the amino-acid, tyrosine, and o-dihydric phenols which are oxidized by the enzyme tyrosinase, to the bluish-black compound known as melanin. One other important practical aspect of these deficient potatoes is their susceptibility to bruising. The blackening of potatoes after cooking is due to melanin only when black or red oxidation products of tyrosine have been formed before boiling. However, potash-deficient potatoes uncoloured before cooking did not blacken on cooking but produced a bluish-green pigment due to the oxidation of a ferrous compound of o-dihydric phenols.

The relationship between high tyrosine content and the supply of either potassium, nitrogen, phosphate, magnesium or copper, show the following trends. Potassium deficiency increased tyrosine content more than any other mineral nutrient. Small increments were shown, in decreasing order, by magnesium, nitrogen and copper.

A marked variation was noted in varietal tendency to blacken, and this was correlated with tyrosine content and susceptibility of the cells to mechanical injury.

Both tyrosine and o-dihydric phenols are distributed unevenly in the tuber, and more tyrosine accumulates in the stem than in the bud end.

The amount of the enzyme tyrosinase falls off considerably in potatoes grown in copper-deficient soil. Thus, potatoes deficient in potassium and copper show less blackening than potatoes grown in a potash-deficient soil but supplied with liberal amounts of copper.

Some Relationships between Molybdenum, Nitrate and Ascorbic Acid Levels in Cauliflower Plants, and the Incidence of Whiptail Symptoms. W. PLANT. *Ann. Rep. Long Ashton Res. Sta.*, 1950, 91-5.

Cauliflowers (var. : Majestic) grown on an acid soil derived from the lower greensand formation, showed symptoms of Whiptail. Applications of sodium molybdate or lime reduced the incidence of Whiptail

from 24 per cent on the control to nil on these treatments. An application of gypsum, however, increased the incidence of Whiptail to 79 per cent.

Estimations of molybdenum, nitrate and ascorbic acid in the leaves of plants in the different treatments showed that a healthy plant contained 0.10-0.80 p.p.m. molybdenum, about 1500 p.p.m. nitrate and about 190 mg. per 100 gm. ascorbic acid. In a plant with severe Whiptail such as found after the gypsum treatment, the molybdenum was 0.10 p.p.m. or lower, the nitrate rose to 2,000-4,000 p.p.m., and the ascorbic acid fell to 130 mg. per 100 gm. It thus appeared that when the symptoms of the deficiency occurred in the plant, the increase of nitrate and decrease in ascorbic acid content coupled with a low molybdenum value could be correlated with this condition.

The diagnosis of Whiptail in the field may be complicated by environmental factors which can apparently induce the same effect on the plant as a shortage of molybdenum. When complex conditions arise the visual diagnosis of Whiptail due to molybdenum deficiency can be verified by ascertaining the nitrate and ascorbic acid values.

W. P.

FLOWERS

Factors Controlling Flowering of the Chrysanthemum. I. The Effects of Photoperiod and Temporary Chilling. W. W. SCHWABE. *J. exp. Bot.*, 1950, **1**, 329-43.

Garner and Allard, in their pioneer work on photoperiodism, classified the chrysanthemum as a short-day plant and it has often been used since in experimental work. American workers have claimed that, in addition to a short photoperiod, high temperatures are required for rapid flowering.

In the work under review plants of the variety Indian Summer raised from cuttings in the usual way, but at different times of year, were grown under short-day (8 hours daylight) and long-day (8 hours daylight plus 8½ hours incandescent light) conditions. Some plants in each light treatment were given low temperature (vernalization) treatment and others high temperatures. Temperatures were not closely controlled but " low temperatures " were below about 8°C. (48°F.) and " high temperatures " at or above 15.6°C. (60°F.) The plants were not stopped and the criterion of " flowering " was the visible appearance of a flower-bud. This was, of course, the natural break-bud.

Vernalization was found to be necessary for, or markedly accelerated, flower-bud formation. Even when grown in long days throughout many of the plants which had received the chilling treatment budded. Unvernalized plants in short days grew vegetatively in most cases and showed a diageotropic reaction, i.e., grew horizontally instead of vertically. A period of 3 weeks' vernalization was always sufficient and the low temperature treatment did not need to be continuous but was more effective in the dark than in the light phase. Little or none of the stimulus was carried over from one year to the next.

This is clearly an important contribution to our knowledge of the problem of photoperiodism in general and of the flowering of chrysanthemums in particular. Certain points emerge, however, that need further clarification and are likely to be dealt with in later publications. It is of interest, in the first place, that this is one of the very few cases where low temperature vernalization is necessary for a short-day plant. The actual limits of temperature required will be interesting to know. From the view-point of practical growing, the subsequent behaviour, not only of the natural break-bud, but also of the later crown buds, in relation to vernalization treatment is of supreme importance. The author suggests that day length is the dominant factor here but hints that temperature may have a close interaction.

It is perhaps unfortunate that a variety so little known, and a Korean variety at that, was chosen for this work, although the author mentions that other varieties behaved similarly on the whole, including Godfrey's Gem, Cossack and Poitevine (? Blanche Poitevene). It would clearly be of interest to study the effect of vernalization on varieties such as Finale, with its irregular flowering habit, and other late varieties. One other point requires clarification in relation to normal cultural practice—the effect of vernalization on plants stopped before the appearance of the natural break-bud. Horticulturists will look forward keenly to later papers from these laboratories.

R.H.S.

HERBAGE

Pre-harvest Chemical Top-killing of Legume Seed Crops. 1. Preliminary Studies with Petroleum Oils, Oil Emulsions and Mixtures of Oil with Potassium Cyanate. W. G. CORNS and G. S. COOPER. *Sci. Agric.*, 1951, **31**, 269-73.

The harvesting of seed of lucerne, red clover and other legumes presents difficulties of drying the crop, particularly since weather conditions in the autumn are frequently unfavourable. The use of top killers and defoliants may be of considerable advantage if applied when the seed is nearly ready for harvest but while the foliage is still green.

In the experiments described in this paper the materials used for top-killing were aromatic weed oil, alone or in aqueous emulsion, or in emulsion with potassium cyanate in small quantity as a fortifying agent. These materials were tested on lucerne, alsike and red clover.

In all species a good kill of leaves and stems was obtained from a spray application of 60 gal. oil per acre. There were slight differences in the effect on the different crops as a result of the varying quantity of foliage to be killed. The use of oil in emulsion produced no apparent benefit as compared with similar rates of oil applied alone. Potassium cyanate at the rate of 6 lb. per acre in conjunction with 2 to 5 gal. oil gave results inferior to larger quantities of oil used alone.

None of the treatments had ill effects on seed germination or injured the crown of the plants.

The use of cyanamid products in dusts and in aqueous sprays has been under test and will be the subject of a later paper.

The Effect of Early Defoliation on Lucerne Seedlings. D. P. BIGNOLI. *J. Brit. Grassland Soc.*, 1950, **5,** 281-6.

This paper reports experiments designed to evaluate quantitively the effect of early defoliation on lucerne seedlings. The treatments included the removal of (a) one and (b) one and a half cotyledons, (c) the removal of the simple leaf only, (d) the removal of the first trifoliate leaf, (e) the removal of first, second and third trifoliate leaves without damage to the growing point.

Most serious reduction of growth followed after treatments (b), and the removal of the first to third trifoliate leaves. Attention is drawn to the importance of seedling injury as, particularly after cotyledon removal, the reduced vigour and growth persisted through the five months during which the plants were under observation. The author considers that, if the effect of cotyledon removal were due entirely to a reduced carbohydrate supply, it could be expected to be of a more temporary nature, and it is suggested that other physiological disturbances are involved.

Pasture Productivity in Mid-Wales. R. O. DAVIES, W. E. G. MILTON, J. R. LLOYD. **Part I. Experimental Methods of Measurement.** *Emp. J. exp. Agric.*, 1950, **18,** 203-17. **Part 2. Botanical Changes in the Experimental Plots : Palatability and " Efficiency " of the Swards.** *Ibid.*, 264-70.

In the experiments described in these papers, pasture productivity was measured under grazing conditions by two methods of herbage clipping, and from the performance of the animals (sheep and lambs) grazing the plots. The data from all methods of measurement were converted into starch equivalent values for comparison purposes. It was considered that the measurement of herbage productivity by clipping from pre-trimmed sites under-estimated grass consumed.

The swards on which productivity was compared consisted of (a) unmanured permanent pasture, (b) manured permanent pasture, (c) 25 per cent ley plus 75 per cent manured permanent pasture, (d) 75 per cent ley plus 25 per cent manured permanent pasture and (e) ley.

The respective liveweight gains per acre were : (a) 261 lb., (b) 270 lb., (c) 322 lb., (d) 326 lb., and (e) 318 lb. Manuring alone gave a small increase of yield over the control, but the liveweight gains from all manured plots containing an area of 25 to 100 per cent reseeded grass were similar, showing an average increase of 23 per cent for these treatments over control. The presence of a 25 per cent strip of reseeded grass was as effective in promoting liveweight increase as if all was reseeded.

Lucerne and the Sitona Weevil. W. DAVIES. *Agriculture*, 1950, **57**, 308-9.

Attention is drawn to the severe damage that may occur to seedling lucerne as a result of weevil attack. Complete defoliation of seedlings may result in a high rate of seedling mortality or a very slow establishment.

Application of 30 lb. per acre of a 5 per cent DDT dust applied about 10 to 20 days after sowing gave effective control of weevil damage.

T. E. W.

GLASSHOUSE CROPS

Red Spider Mite

This mite is the most serious of the insect pests attacking glasshouse crops, at any rate in the south of England. The incomplete kill of adult mites by azobenzene necessitates frequent applications to prevent increase in the mite population, and at Cheshunt, the acaricidal values of several organic phosphorus compounds have been investigated.

Pests of Greenhouse Crops. Insecticide Investigations. W. H. READ. *Cheshunt Exp. Res. Sta. Ann. Rep.*, 1948, 51-3 ; 1949, 57-61 1950, 40-41.

Determination of the ovicidal activities of HETP and TEPP towards the eggs of the greenhouse red spider mite (*Tetranychus telarius*) by a dipping technique show that these substances have no appreciable ovicidal value and that the toxicity to the eggs is closely related to the tetraethyl pyrophosphate content. Both are highly effective against active stages of the mite but TEPP (36.9 per cent tetraethyl pyrophosphate) gave 100 per cent kill at a concentration of 0.01 per cent, whereas HETP (20.3 per cent) required a concentration of 0.018 per cent to give a 100 per cent kill of adult females.

In the course of the glasshouse trials with these insecticides it was found that young tomato plants were injured by sprays containing 0.025 per cent TEPP or 0.05 per cent HETP when the plants were kept at

80°F., and under conditions of low humidity (52 per cent r.h.) for six hours after treatment. The effect was a hardening of the plants due to downwards incurling of the leaf edges and ultimate reduction of leaf expansion. At 50°F., or at high temperatures under humid conditions, no injury resulted at the same concentrations. At spray concentrations of 0.05 per cent TEPP and 0.1 per cent HETP young tomatoes were severely scorched, particularly when retained in a dry atmosphere after treatment. At these concentrations, plants 3 ft. high were damaged on a number of occasions, although the resistance of the plant increases with age. Subsequent trials showed that these materials were not effective as aerosols, either on their own for controlling the active stages of the mite, or for increasing the action of azobenzene on active stages when used in azobenzene—TEPP (or HETP) mixtures.

PARATHION (E.605). As this substances is more volatile than HETP or TEPP, it is more physically suitable for the control of pests in glasshouses by the aerosol or smoke methods. At 0.3 gm. per 1000 cu. ft. a complete control of the active stages of red spider was obtained, but a mixture of 0.3 gm. parathion and 4 gm. azobenzene per 1000 cu. ft. gave results superior to those obtained from 6 gm. azobenzene per 1000 cu. ft. In these tests it was observed that 1 gm. parathion per 1000 cu. ft. killed adult white flies and thrips. Owing to the highly poisonous nature of the parathion-azobenzene mixture, the aerosol method of applying this is now regarded as quite unsuitable. In practice, parathion is mainly used in the form of smokes, and a number of proprietary smoke generators have given satisfactory results, but more information regarding the hazards accompanying the use of parathion smokes is required. The combination of azobenzene as an ovicide with parathion, whilst giving a good control, has certain disadvantages, as azobenzene hardens the growth of young cucumbers to such an extent that its use on plants in pots or recently planted out, is not advisable. Strains of the red spider mite resistant to parathion have recently arisen in America and there is evidence that similar resistance is occurring in this country. Accordingly, alternative compounds for the control of this pest are being sought, and preliminary trials with some of the newer synthetic organic compounds, show some promise.

E. S.

ENTOMOLOGY

Toxic Chemicals in Agriculture. *Report to the Minister of Agriculture and Fisheries of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture.*

The report of this Working Party, under the Chairmanship of Professor S. Zuckerman, gives a full account of findings of the Committee on the various aspects of an important problem. It is important that all who are concerned in any way with the use of toxic chemicals in agriculture should acquaint themselves with the contents of this report.

The case for the use of toxic chemicals is examined and it is stated that these substances offer some of the most satisfactory means yet discovered for the control of pests and weeds. They are of great value to the efficient production of food in this country.

The dangers to man and the mode of action of the chemicals is discussed. Facts are given about the accidents which have occurred. Protective measures stated to be currently in use are reviewed, and a number of additional protective measures were suggested in the evidence received from various organizations.

A complete list of important recommendations appears at the end of the report.

Studies on the Ox Warble Flies, *Hypoderma lineatum* and *Hypoderma bovis*. W. J. Bevan and E. E. Edwards, *Bull. ent. Res.*, **41,** April, 1951.

A historical account of the two species of ox warble flies is given, together with a discussion of their economic importance. The degree of incidence of this trouble is high in South Wales, where the investigations were carried out. Over 80 per cent of the cattle included in surveys conducted in 1945 and 1946 were infested to varying degrees ; in one case 152 larvae were recorded on a Shorthorn heifer.

The larvae spend some 42 days in the tissues of the backs of the cattle. Herds on upland pastures were found to be generally less liable to severe attacks than those in lowland farms. Cattle under three years old are usually more heavily infested than the older animals.

DDT and benzene hexachloride preparations were found to be ineffective for killing the larvae, but DDT emulsions sprayed on the legs and flanks of cattle during the period of oviposition (end of May to mid August) were promising and further work is warranted. Applications would probably have to be made every 14-21 days during the oviposition period.

L. N. S.

Indexing Potatoes for Virus X, including the Use of Tuber Juice. W. G. Hoyman, *Phytopathology*, 1951, **41,** 18.

These experiments confirm that pepper, *Capsicum annuum*, is not entirely reliable as a test plant for the presence of virus X. *Gomphrena globosa*, the globe amaranth, is more satisfactory as an indicator for this virus.

A total of 1,378 potato plants of the varieties Bliss Triumph, White Rose and Cobbler were indexed on 36 varieties of *Capsicum annuum*. Of these 98 were negative, but further testing indicated they were infected with virus X.

A rapid method of testing was to rub the cut surface of the tuber on the leaves using No. 400 carborundum powder. Of 3,763 tubers of Pontiac, Bliss Triumph, Cobbler and Green Mountain tested in this manner, 19 gave no reaction. From a second test of these 19 negative tubers, 17 reacted and the remaining 2 were Cobblers which gave no reaction when tested the third time. However, sap from the leaves of plants grown from those two tubers gave a positive reaction on *G. globosa.*

Methoden zum Nachweis der Wichtigsten Kartoffelvirosen. F. Sprau, *Pflanzenschutz*, 1949, **1,** 78-83.

Four methods of diagnosis of the chief potato viruses are described—tuber indexing by means of eyes or shoots, aphid transmission, the use of indicator plants and the serological technique.

Variation in Virulence of Potato Virus Y in Isolates from Different Sources. R. N. Larson and G. F. Darby. *Phytopathology*, 1951, **41,** 23.

Under greenhouse conditions, 18 isolates of the potato virus Y obtained from field material from various sections of the United States and from other laboratories, differed markedly in type and severity of symptoms produced, as well as in relative virulence. Some isolates were virulent to the extent of killing certain potato varieties while affecting others only slightly.

No immunity to any of the 18 virus Y isolates was found in 30 wild and cultivated species of *Solanum* from South and Central America.

The following plant species were found to be good local lesion hosts for most of the isolates : *Physalis peruviana* L., *Lycium hamilifolium* Mill. and *L. rhombifolium* Dippel.

Verordnung zur Bekämpfung der Viruskrankheiten der Kartoffel. *Pflanzenschutz*, 1949, **1,** 89-90.

This order for the control of potato virus diseases in Bavaria has two parts : the first is directed towards the extermination of the aphid *Myzus persicae*, and the second is designed to reduce the infection coming from infected crops.

As regards the campaign against the aphid, peach trees must be sprayed with a winter wash and owners must register with the local police every year before October 1 any peach trees on their property.

In " closed " areas where seed-potato production is carried on, nurserymen must also deal with infestations on their plants under glass.

The second part of the order forbids the use of tubers as " seed " from crops with more than 10 per cent virus diseased plants.

Investigations on the Strains of Potato Virus X in Ultraviolet Light. A. A. KOZLOWSKA. *Extrait du Bull. de l'Académie Polonaise des Sciences, Série B., Sciences Naturelles*, 1949, **I,** 215-32.

Virulent strains of virus X always show on tobacco leaves a characteristic fluorescence in U.V. light. On the other hand, on tobacco leaves infected with masked virus X, serologically confirmed, fluorescence appears in U.V. light in a varied intensity, sometimes being absent altogether.

The following facts concerning the nature of the fluorescence have been obtained :

1. The virus nucleoprotein extracted from the plant tissue does not itself show fluorescence.
2. The phenomenon is especially pronounced on infected tobacco ; on other species infected with virus X, notably potato, it is not visible.
3. Fluorescence on tobacco leaves is not directly correlated with the intensity of the disease.
4. A distinct fluorescence appears in the first month after infection, disappearing in the later stages although virus X is still present.

Effect of Tobacco Mosaic Disease on Yield of Tomato. L. J. ALEXANDER, *Phytopathology*, 1951, **41,** 1.

Experiments have been conducted to determine the loss in yield caused by the Tobacco Mosaic disease of tomato. It was previously reported for 1949 that Tobacco Mosaic reduced the yield in a glasshouse 13.2 per cent, and that the greatest reduction occurred during the early part of the season. In 1950 a similar experiment with glasshouse tomatoes confirmed the 1949 results. However, in 1950 the experiment was enlarged to include a comparison of the effect of the disease on the two varieties Strain A Globe and Ohio W. R. Globe. Early mosaic infection reduced the total yield 7.9 per cent, whereas in 1949 the reduction was 13.2 per cent. There was no reduction in total yield with Ohio W. R. Globe.

The early production of both varieties was considerably reduced. Reduction in yield is occasioned by poor fruit set. Plants of the variety Strain A Globe infected January 18 set an average of 2.95 fruits per cluster for the first two clusters, whereas plants infected later, approximately May 15, set 4.55 fruits per cluster. Plants of the variety Ohio W. R. Globe, infected January 18, set an average of 3.35 fruits per cluster for the first two clusters, whereas plants infected later set an average of 4.6 fruits per cluster.

Virus Diseases. R. Howles. *Experimental and Research Station, Cheshunt Ann. Rep.* 1949, 33-8.

Howles finds that spraying with 1 per cent tannic acid once a week delays the spread of aucuba mosaic between tomato plants by contact, and that an anti-virus paste on the hands and knife reduces transmission during handling of the plants.

Indications of a New World Origin of Tobacco Mosaic Virus. Francis O. Holmes. *Phytopathology*, 1951, **41,** 17.

A study of solanaceous plants, especially in the genus *Nicotiana,* has disclosed evidence supporting the hypothesis that Tobacco Mosaic virus has a New World origin. Areas characterized by relatively resistant species and varieties are centrally located within larger areas characterized by closely allied but highly susceptible species. Tobacco Mosaic virus is now essentially world-wide in distribution, probably as a result of diffusion of tobacco products by commerce. It seems probable that its distribution was more limited formerly and that its long-continued presence in the areas now characterized by relatively resistant host plants was responsible for reduction of competitive vigour in susceptible species there, with resultant encouragement of resistant mutants.

Eine Viruskrankheit des Kopfkohls *(Brassica oleracea* L.) ? Vorläufige Mitteilung. C. Buhl. *Nachr. Bldtsch. PflSchDienst Braunschw,* 1950, **2,** 53-4.

A suspected virus disease of cabbage especially late white, red and Savoy crops has been observed in parts of Schleswig-Holstein. Symptoms consist of a characteristic yellow sectoring of the older leaves followed some time later by a marked browning and shrivelling. Black necrotic spots develop in the hearts with extensive mottling and vein clearing on the young inner leaves. In the early stages of the disease affected plants may be detected by the absence of the blue-green wax coating found on normal leaves.

Broccoli Mosaic. I. W. Prentice. *Agriculture,* 1950, **56,** 577-9.

The symptoms and possible means of control of the Broccoli Mosaic disease are described. If these measures are unsuccessful it is recommended that crop rotation should be modified so that for at least a month the farm would be free of all types of *Brassicae.* Seedlings could be raised in another district where the virus was less prevalent or broccoli could be left out of the rotation for a year.

Virus Diseases of Fruit Trees. A. F. Posnette. *The Fruit-grower,* 1950, No. 2838, 861-2.

The virus diseases of fruit trees are being studied at the East Malling Research Station and growers can help by reporting cases of suspected virus symptoms. A number of diseases are briefly described—Apple Mosaic, rubberiness and chat-fruit ; the two latter are especially common in the variety Lord Lambourne. In addition, stony pit and vein-

banding in pears, mosaic and vein-banding in plums and four suspected virus diseases of cherries are mentioned. The cherry diseases are cherry rasp-leaf, tatter-leaf, vein-banding and ringspot.

" Little Cherry " has not yet been recorded in Great Britain but is a severe disease in Canada.

Viruskrankheiten im Obstbau. S. BLUMER. *Schweiz. Z. Obst-u. Weinb.*, 1950, **59,** 63-6.

The group of virus infections in cherry in Switzerland are becoming of increasing importance, especially the so-called Pfeffinger disease. Shoots are poor and the leaves may bear green or yellow lesions ; they may be small, narrow, and dry with sharply dentate edges. Sometimes the leaf veins are swollen with prominent, dark green spots or excrescences.

Control measures should consist of careful selection of nursery stocks, and scions for grafting should never be used from infected areas.

K. M. S.

SOILS

Molybdenum and Lucerne Production

Investigations on the effect of molybdenum on lucerne recently reported by Evans and Purvis from the New Jersey Agricultural Experiment Station[1] are perhaps of special interest in view of the development of the lucerne crop in this country.

Failures of New Jersey alfalfa crops through unknown causes led to the conclusion that these failures might be due to lack of molybdenum. Bortels (*Arch. Mikrobiol.*, 1937, **8,** 13-26), in Germany and Anderson (*J. Aust. Inst. Agric. Sci.*, 1942, **8,** 73-5), have reported beneficial effects of molybdenum salts on the growth of lucerne and other legumes. Accordingly, the molybdenum content of a number of representative New Jersey soils and alfalfa crops was examined by the method of W. O. Robinson (*Soil Sci.*, 1948, **66,** 317-22).

The molybdenum contents of the soils varied between 0.8 and 3 p.p.m., averaging 1.44 p.p.m. ; that of alfalfa collected from nine centres varied from 0.1 to 1.4 p.p.m., averaging 0.88 p.p.m. There was no significant variation in the Mo. content of different varieties of alfalfa grown on the same farm.

When plots of established stands of alfalfa on six farms were treated with sodium molybdate at the rate of 1 lb. per acre, statistically significant increases in the total yield from three cuttings during the season were obtained at four out of the six farms. These increases were correlated inversely with the Mo. content of untreated alfalfa plants on the same farm.

The Mo. treatment also appreciably increased the nitrogen uptake of alfalfa at four of the farms. Mo. is believed to benefit alfalfa by increasing nitrogen fixation, but in the experiments under review there appeared to be no consistent relationship between numbers of nodule masses and Mo. treatment or the nitrogen content of the plants.

Evidence is given in a further report by Evans and Purvis[2] that soil *p*H is a major factor controlling the availability of soil Mo. to crops. They conclude that Mo. is present in acid soils in an unavailable form and that it is made available by liming to near neutrality. Thus, the Mo. contents of alfalfa plants grown on plots limed to *p*H 6.1 to *p*H 6.5, ranged from 0.7 to 1.1 p.p.m., that from alfalfa grown on plots limed to *p*H 6.9 to *p*H 7.6 containing 1.6 to 3.0 p.p.m. Mo. This effect of soil reaction on the uptake of Mo. was confirmed in parallel pot experiments with alfalfa grown on soil of four different *p*H values. Other tests confirmed that the increased Mo. uptake was due mainly to soil reaction and not to the Mo. content of the liming materials used.

Soil reaction does not appear to be correlated with the total Mo. content of soils, though it is believed that the very low content of Mo. in alfalfa plants grown on some naturally neutral or slightly alkaline New Jersey soils may be due to the loss of Mo. from the soils by leaching at the high *p*H values that occurred during the soil forming process.

Analysis of fertilizers and liming materials indicated that the amounts of soluble Mo. they contain are not adequate to meet the requirements of legumes.

References

1. Molybdenum Status of Some New Jersey Soils with Respect to Alfalfa Production. H. J. EVANS and E. R. PURVIS. *Agronomy Journal*, 1951, **43,** 70-1.

2. Effect of Soil Reaction on Availability of Molybdenum. H. J. EVANS, E. R. PURVIS and F. E. BEAR. *Soil Sci.*, 1951, **71,** 117-24.

A.J.L.L.
W.M.D.

Nitrogen in Soils

There has always been a problem in giving advice on the use of nitrogenous fertilizers, especially to horticulturists, because of the wide range of fertilizers of this type in general use, with their division into organic and inorganic varieties, and the difficulty of applying the concept of " availability " to them.

Some progress has been made recently in comparing the availability of such materials as dried blood, hoof and horn, bone meal, plastic waste, sulphate of ammonia, urea, leather meal and shoddy, by incubating samples of soil brought to a standard moisture content in the presence of a little free calcium carbonate and determining the progress of nitrification at intervals. One worker (J. H. Hamence, *J. Sci. Food Agric.*, 1950, **1,** 92) has used dried blood as a standard of reference and has produced a useful table of comparative availabilities :

Dried Blood = 100

Meat and bone meal	102	Bark tanned leather ...	Nil
Fish meal	129	Chrome leather	8
Hoof and horn meal	100	Treated leather meal ...	50
Shoddy	90	Plastic by-product (containing 22 per cent N) ...	11
Sulphate of Ammonia ...	112	Urea	170

The most striking features of the table are :

1. The high availability of hoof and horn, and of shoddy.
2. The low availability of leather (unless treated) and of plastic waste.
3. The high value given to urea and its rapidity of nitrification.

Confirmation of the surprising results given with hoof and horn is provided by Owen of Cheshunt, who has been working with some of his colleagues on the nitrification of some nitrogenous fertilizers and the effect on the process of giving them at various levels (*J. agric. Sci.*, 1950, **40,** 185 and 191). This work arose from the necessity during the war of using dried blood in base dressings for tomatoes to replace hoof and horn which was scarce. It had always been assumed that hoof and horn was fairly slow in action, whereas dried blood was relatively rapid, and therefore it was usual to apply hoof and horn to the soil before planting so that it would become steadily available over the following couple of months or so, while dried blood was reserved for rapidly acting top dressings. It was therefore to be expected that the substitution of dried blood for hoof and horn would lead to undesirable bush growth in the early stages of the tomato plants. In practice, this did not occur and the explanation was sought.

In this work samples of several standard soils were mixed with a range of nitrogenous fertilizers at a uniform proportion of nitrogen to each plot and the nitrate nitrogen produced was determined over a period of 65 days. This method differed from Hamence's in that the moisture content and temperature were not standardized nor was calcium carbonate added. The curves obtained showed that guano was very much more rapidly nitrified than dried blood, fish meal, hoof and horn, bone meal or hoof—in fact most of it was nitrified in a week. A bone meal was also rapid and was then followed by the others. It was interesting that in some soils there was a denitrification for the first week when hoof and horn, or horn were used. Further experimental work showed that sulphate of ammonia is as rapid in action as guano.

The most striking results were :

1. Dried blood and hoof and horn are about equally rapid in action, though both are relatively slow-acting in comparison with sulphate of ammonia or Peruvian guano.
2. The availability of bone meal varies widely from one sample to another.
3. Horn meal and hoof meal used separately are nitrified less than the mixture of these—horn being the slowest of all the fertilizers tested.
4. Some measure has been obtained of the speed of action of these materials. Thus, in one trial, at the end of four days bone meal was superior to dried blood or hoof and horn ; on the sixth day hoof and horn and bone meal were of equal value ; on the seventeenth day bone meal was inferior to both the others.

5. In some soils sulphate of ammonia is nitrified to 90 per cent in six days.
6. Confirmation has been obtained of the fact known from practice that the normal top dressing mixture for tomatoes of 10 per cent sulphate of ammonia, 50 per cent dried blood and some nitrate, is exhausted in fifteen to sixteen days. The nitrate is immediately available, the sulphate of ammonia comes into action during the first six to ten days and the dried blood is largely decomposed in fourteen to sixteen days.

When similar trials were made with each fertilizer applied at three rates of dressing, it was found that the percentage nitrified by a given time varied considerably from one rate to another for urea, sulphate of ammonia and guano, whereas with dried blood and hoof and horn the percentage nitrified was independent of the rate of application. Bone meal and diammonium phosphate are intermediate between the other two groups.

The explanation of this is probably that for dried blood and hoof and horn, the rate of conversion of the nitrogen in the fertilizer to ammonia is no greater than that of the conversion of ammonia to nitrate, whereas for guano, urea and sulphate of ammonia, ammonification at higher rates of dressing can be too rapid for the nitrifying organisms to sustain, and so free ammonia will increase in soils when the most rapidly acting fertilizers are used.

The Availability of Nitrogen in some Bone Materials used in Horticulture. M. I. E. LONG, O. OWEN and G. W. WINSOR. *J. Sci. Food Agric.*, 1951, **2**, 125.

In earlier work on the rate of nitrification of a number of fertilizers such as hoof and horn, guano, dried blood and bone meal, Owen, Rogers and Winsor (*J. agric. Sci.*, 1950, **40**, 185) noticed that two samples of bone meal had very different rates of decomposition. The work has been developed in this paper and 16 commercial samples of bone meal with total nitrogen contents ranging from 2.12 per cent to 5.55 per cent, with a mean of 4.11 per cent, have been examined. The wide differences in nitrogen can arise from the origin or treatment of consignments or from decomposition in storage.

The samples varied in fineness of grinding from having particles of maximum size 2 mm. to 60 mm., and colour and smell were also very variable.

By incubating with a standard soil at 23.5°C. for nine days samples of each lot adjusted to give a concentration of 300 p.p.m. added nitrogen in the mixture, the fractions of nitrogen converted into nitrate and ammonium nitrogen were determined and were found to vary considerably (as a sum of both forms) from 48.1 p.p.m. to 2.9 p.p.m. The order of merit found in this way was not necessarily related to the total percentage of nitrogen in the various samples of bone meal.

The results given by the soil tests were compared with the water-soluble nitrogen, the percentage of ammonia released on distillation with magnesia, and the percentage passing 60, 80 and 100 mesh sieves

after milling through a 1 mm. grid. All gave a positive correlation especially the water soluble nitrogen and 60 mesh sieving, with a significance $P = 0.001$. Negative correlations of fair significance were obtained with bulk densities and *p*H of 2 per cent aqueous suspensions.

The water-soluble nitrogen, with a correlation coefficient of +0.845 on the 9-day test, affords a useful measure of availability of samples but breaks down when the rate of decomposition of bone meal in soil is particularly high. It is, all the same, useful for differentiating between samples of lower availability. Taken in conjunction with bulk-density or sieve-analysis on milled samples, the water-soluble nitrogen test is a very sound guide to the usefulness of any sample.

The physical tests on milled samples are related to the ease of breakdown of samples in the mill rather than to the particle size of the original materials. Examination of samples showed that they contained a friable constituent with a relatively high water-soluble nitrogen content. Pure bone is reasonably constant in availability, but the marrow, cartilage and softer material vary more in composition and the proportion of them in a specimen of bone meal will have a notable effect on availability of nitrogen.

J.B.E.P.
W.M.D.

MACHINERY

Agricultural Engineering Research in Sweden

The Swedish Institute of Agricultural Engineering at Ultuna, Uppsala, has published a number of illustrated bulletins, with summaries and captions to the illustration in English ; seven are detailed below :

BULLETIN No. 227 (1949), *Trench Digging by Wheel-Type Trenchers*, deals with the working of self-propelled machines such as the American " Buckeye " and " Parsons " trenchers. The tiles could be laid directly behind the machine, when one extra man riding on the machine could look after the tile-laying, and one other man was needed to join up laterals to the main drain. Where, however, the slope was slight, it was considered preferable to scoop the bottom of the drain by hand and lay the tiles as a separate job. Direct laying by machine was preferred where the slope was good and where the trench walls crumbled easily. Average rates of work with tiles laid direct by the machine ranged from 525 to 1,610 ft. per day. When the tiles were laid later, working rates of the machine ranged from 590 to 1,970 ft. per day.

BULLETIN No. 225 (1949), *Influence of Combining on the Quality of Grain*, describes research on the effects of ripeness and of moisture content at harvest time on the quality of grain harvested by various methods. Among the interesting conclusions reached were :

1. Good threshing and cleaning could not be expected until after the grain had reached a degree of ripeness indicated by a moisture content of 20 per cent. After this stage, cleaning of the sample was not much affected by changes in moisture content caused by weather conditions.

2. Kernels damaged by the threshing machine or combine could be found in all samples threshed when the moisture content exceeded 20 per cent. This damage occurred whether high moisture content was due to unripeness or to rainy weather.

3. The mechanical damage by threshing at high moisture content was associated with reduced germination.

4. Baking quality was not influenced by the moisture content at threshing.

BULLETIN NO. 219 (1948), *Hitches for Tractor-Drawn 4-Wheeled Waggons*, consists of a survey of common types of drawbars and hitches, and describes two new types of easily connected self-centring hitches developed by the Swedish Institute of Agricultural Engineering.

One of the new hitches described and illustrated employs a vertical pin on the tractor drawbar and an eye at the front of the trailer drawbar. The front of the trailer drawbar consists of a horizontal, roughly V-shaped steel plate, with round steel bar welded to its lower edges and continued forward at the front to form the hitch eye. The trailer drawbar is propped up by means of a hinged support, and the tractor is backed until the hitch pin is beneath the area of steel plate. When the trailer drawbar is lowered on to the tractor pin and the tractor moves forward, the guide bars ensure that the trailer eye drops down over the tractor drawbar pin. The hitch is then locked by means of a lever on the tractor drawbar.

A second type of hitch employs a short swinging arm which is telescopic until locked, so that the clevis attached to the front can be swung with ease over a considerable area. When the connection to the tractor drawbar has been made, the tractor moves forward, the hitch arm automatically centres itself and is locked in position. For use with this or any other drawbar which employs a tongue and a plain hole in the tractor drawbar, a simple safety hitch pin with a spring locking device has been developed.

Time studies showed that use of the drawbars developed achieved considerable saving of time, and helped to reduce the risk of serious accidents.

BULLETIN NO. 224 (1950), *Pneumatic Tyres for Farm Vehicles*, gives the results of research on 16-inch and 20-inch diameter transport tyres, of various widths from 6-9 inches, used in a wide range of conditions on both 2-wheeled and 4-wheeled trailers. Other factors studied included the effects of tyre pressures and tyre design, and the influence of the construction of the vehicle frame and the angle of draught. The results obtained on very soft land (wet beet fields) are of much interest, and among them the following are worthy of note :

1. When the vehicles were loaded so as to exceed the weight that the tyres were designed to carry, overloading considerably increased the rolling resistance, and the increased draught was proportional to the degree of overloading.

2. Taking into account the different relationships between tyre inflation pressure on the one hand, and load carrying capacity and rolling resistance on the other, the optimum inflation pressure for general use was found to be 3-4 Kg./cm.^{2} (i.e., 42-56 lb. per square inch).

3. Rolling resistance of 20-inch tyres was from 0 to 10 per cent less than that of 16-inch diameter tyres of the same width, while an increase of 1 inch in tyre width from 6 to 7 inches produced about the same decrease in draught as this increase of 4 inches in diameter.

4. There was little difference in draught between a 2-wheeled and 4-wheeled trailer on wet beet fields, but on dry loose land, draught of the 4-wheeled vehicle carrying a given load was appreciably less (up to 20 per cent)

BULLETIN No. 209 (1947), *Instructions in the Use of Draining Ploughs*, gives advice on the use of a simple trencher called Aashamar's draining plough. This machine consists of a thin U-shaped share designed to make a cut 7-7½ inches wide and 2-4 inches deep as the trencher is pulled forward. The slice cut out is forced on to a sloping conveyor chain, the latter being driven by a wheel which carries the weight of the machine and runs in the bottom of the trench. The depth of the trench can be steadily increased to about 4 ft. if necessary. This is essentially a farmer's tool, which will only work well in good conditions, and fails in very soft, very hard or stony land.

BULLETIN No. 215 (1948), *Trench Digging by Universal Excavator*, deals with the operation of a self-propelled dragline excavator fitted with a special trenching bucket which has a loose bottom. This was found to be the only type of machine capable of dealing with very stony land. The average speed of work was 800 ft. per day.

BULLETIN No. 223 (1949), *Combining Grain at a Low Moisture Content*, describes studies of changes in moisture content of standing corn crops from the time when they were fit to cut by binder until it was too late for successful harvesting by combine. Conclusions drawn include the following :

1. After the grain had reached binder ripeness, its moisture content was strongly influenced by even small amounts of rain, and the deciding factor was not the total amount of rain that fell, but the length of the rainy period.

2. Oats were most sensitive to changes in the weather, barley rather less, and wheat least affected. Thus, after a lengthy period of rain, oats lost moisture quickest when dry weather followed, and were ready to combine first. After a short rain, however, wheat, which was slowest to suffer from the wet, was soonest fit after it.

3. In the unusually wet harvest of 1948 in Ultuna, moisture contents were below 20 per cent for only 130 hours between the normal working hours of 7.0 a.m. and 9.0 p.m., and for 180 hours if periods between 9.0 p.m. and 7.0 a.m. were taken into account.

C.C.

PROVINCIAL NOTES

FARMING ON THE MIDLANDS LIAS

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The lower lias which runs like a deacon's stole across the body of England is noted for its heavy soils. About a third of Warwick and a quarter of Worcester is covered by this formation and though the soil pattern is complicated by drifts—two glaciers seem to have converged here—the prevailing type is claggy clay, known, rightly enough, as four or five horse land. It is almost impossible to walk arable land in wet winters, so heavy are the clods which boulter the feet. In what follows I have tried to draw together information derived from a number of colleagues—in particular W. E. Gelling and J. S. Hopkins—and a number of farmers on the land in question.

The history of farming on this belt has, until recent times, been a dismal tale ; latterly it is something of an epic. The lias was all ploughed in the eighteenth and nineteenth centuries but the high ridges into which it was thrown up attest the difficulties of drainage. A good deal was written about the subject at that time (Elkington was a Warwick man) and, no doubt, much stone and pipe drainage was done, but a good deal of the land is, to this day, undrained. The whole area passed into grass of sorts as prices of corn fell. The plough came back in 1939, hitched this time to power such as no teams of horses could develop ; new implements were imported or evolved, and bold expedients were employed in using them. The A.E.C.s not only directed the campaign, but themselves engaged in farming on a considerable scale ; Warwick, by 1945, was operating 64 crawler tractors and had over 3,000 acres of lias land in hand.

During the war, the tillage area was raised to nearly 50 per cent. Most of the ploughed land was used for wheat, to a lesser extent for oats. Little barley was grown and an insignificant area was devoted to green crops whether for cash or fodder.

Not unnaturally, Take-all and Eyespot had appeared before the end of the war and it has since remained a potential threat to cereal cultivation. Heriff (*G. aparine*) and corn buttercup became real menaces over large areas, necessitating spraying. Wild oat and, sporadically, chalk weed (*Cardaria Draba*) and wild onion, also became troublesome. Cattle stocks remained stable during the war and have since risen to well above pre-war level ; sheep, reduced drastically, now number rather more than half the pre-war strength. The C.E. figures are interesting ; they conform almost exactly to text-book standards. Under new management the land is now keeping heavier stocks than the land and the cake merchants could contrive between them. (The improvement in Warwick since the N.A.A.S. came into being is striking !)

To illustrate the changes the following figures may be cited from representative areas in the two counties—3 parishes in Warwick and 2 in Worcester.

Men, Crops and Stock per 100 Acres

	Warwickshire Average size holding 105 acres			Worcester Average size holding 40 acres		
	1939	1944	1950	1939	1944	1950
Farmers	0.9	0.9	0.9	2.5	2.5	2.5
Workers	0.9	1.5	1.6	1.1	1.9	1.7
Wheat	1	31	19	1	25	13
Other Grain	1	12	15	—	11	11
Green Crops	—	2	1.5	—	2	1
Tillage	4.5	49	37	5.4	45	33
T.G.	0.5	12	18	0.6	7	13
P.G.	95	39	45	94	48	54
Cows	7	6	8	5	6	9
Total Cattle	27	26	33	28	28	35
Sheep	100	37	65	64	30	33
Horses	3	2	1	2	2	1
C.E.	37	24	33	29	24	28
Acreage Fodder Crops* per C.E.	2.7	2.9	2.4	3.4	3.1	3.1

* All crops other than wheat.

It is impossible to doubt the general success of the ploughing campaign. Though the difficulties of cultivation are immense and the risks considerable, the potentialities of the lias clay are great. Whether or not these potentialities are realized is mainly a question of management. (It is easy to be carried away by the excellence of outstanding farms and to forget the average.) Winter wheat on good holdings often yields 2 tons per acre, and 30 cwt. is common, though the average yield is but 20 to 22 cwt.; Spring wheats thrive well but yield less. Barley, grown in increasing quantities since the war, also yields well. In certain years beans produce forests of haulm, heavily podded; the crop remains, however, a speculative one. Leys of quite outstanding merit can be established by anyone who cares to follow a few simple rules. It has, however, taken time to develop the technique needed for successful management of this difficult land. Of the many lessons learned, six seem to stand out.

Drainage

Nature has decided that the lias is wet, retentive land liable to waterlog in winter, and cold, slow drying and late in spring. No system of surface

management yet evolved can overcome these defects. Deep drainage is essential. This need not be effected entirely by pipes. Moles serve equally well on fields of sufficient slope. But drainage either by pipe or mole there must be to justify the costs and risks of cultivation.

Depth

In days gone by the lias was seldom ploughed more than 6 or 7 inches (or somewhat deeper when, at long intervals, steam was employed). The subsoil is a clay of the consistency of a glazier's putty. Yet such land can safely be ploughed to a depth of 14 or 16 inches. Naturally it is prudent not to increase the depth by so much " in one go ". Whatever the increased depth be, raw clay is brought to the surface. Frost, drying winds and alternating rain quickly make it possible to incorporate the new layer in the surface soil ; for the lias " humbles " easily.

Deepened soils have a water relationship completely different from that of soils of traditional depth. They do not easily waterlog ; they are workable in the spring long before soils of natural depth, and consequently they are earlier.

Organic Matter

All clay farmers are familiar with the fact that ploughed-out turf is drier land to work than old tillage. On the lias it has been the general experience that cultivations are easiest the first year and become progressively more difficult as the sod disappears. But old turf consisting mainly of *agrostis* is shallow rooted. A good ley, especially of cocksfoot, seems to have as high a value in death as in life, by reason of the fibre it adds to the soil. Maintenance of fibre is certainly one of the keys to lias management.

Speed

Be the standard of management what it may, the length of time available for autumn and spring work is very restricted. In most years work must cease in November. In the spring the land passes over quickly from putty to wind baked bricks. All work must be concentrated into a few crowded weeks. Winters like that of 1950-51 are a severe test to lias farmers. Fields unploughed in the autumn are unworkable until late in the spring; they present the farmer with the dilemma of a scrambled crop of spring corn or a bare fallow. The former often results in poor brairding, a weedy crop, and a low yield. The latter means no crop for the season, but gives a chance of cleaning the land and naturally ensures an early and probably large wheat crop in the succeeding year. And who shall say which is the better of the two ?—a half crop of oats and a doubtful crop of wheat, or one good crop of wheat ? Usually the former is regarded as the lesser of two evils so that the area of bare fallow rarely exceeds 5 per cent of the arable land. Probably the solution of the cropping problem in a bad spring is direct seeding to grass.

Power

Though there are productive farms equipped only with a major tractor, high power is a great asset. At least one deep ploughing—before

the ley—seems essential in every rotation. Ploughing should start in July or August when quite often the land is so hard that only a crawler and a plough of prairie buster or Jumbotrac dimensions can work it. Moreover, the *quantity* of tractors and tools needed to manage land successfully is far in excess of that called for on more tractable land.

Fertilizers

It is futile to try to farm the lias without phosphates and farming opinion veers towards " little and often " as opposed to Gilchrist's famous slogan of " 10 cwt. high-grade basic slag ". Lime is rarely required ; potash but seldom.

As elsewhere, systems of management are to some extent dictated by events of days gone by.

Warwick

On the Warwick lias, early settlement was in nucleated villages and there were large open fields managed on the 3-field system. This area was one of the last to be enclosed and when enclosure was effected it was effected under the dominating influence of owners and agents interested in securing tenants of substance ; so farms of considerable size were laid out, relatively isolated and self-contained. Throughout the era of the great landlords, however, the fox and the pheasant were big factors in estate management. The latter part of the nineteenth century and the earlier part of this saw the decline both of arable farming and of squires. Fixed equipment of estates degenerated. Dairy farming increased to some extent, but water supplies on the lias are indifferent and there was comparatively little development of public mains ; and on many farms buildings remained unimproved. The majority of the farmers became rearers of stores, sheep graziers, summer beef feeders or something closely resembling mere dealers ; almost everywhere labour sank to a low figure. On some holdings farming degenerated to ranching and the thorn, brier and anthill grew apace. Of course, some farmers contrived to keep the flag flying ; though a bit " browned off " and prone to seek ways of making a living somehow without too much work, they were able to respond to the call of 1939.

Bad though times had been, they were sufficiently sound underfoot to capitalize arable farming and sufficiently alert to learn the ways of the crawler tractor and the combine. They remain primarily stock farmers, though more than half their land is still under the plough. Whether it can be regarded as " in rotation ", and how much of it can rightly be classed as arable land within the accepted meaning is a matter of opinion. Everyone is still living more or less hand-to-mouth and the pattern of land management bears a strong resemblance to that of the Celts who grew corn as long as the land would produce anything, then let it revert to grass which they reploughed when they felt like it. If this can be called a rotation, the Warwick rotation is grass . . . grain . . . grass . . . Naturally the more convenient fields are seeded to short leys ; on the less convenient the land is left for three or four years, while on some fields the chances of reploughing are regarded as so remote that the occupier feels justified in returning them as permanent grass.

The standard seeds mixture is probably still 24 lb. or thereabouts of ryegrass, red clover and wild white, or ryegrass, cocksfoot and the same clovers. Ryegrass has, however, but a short productive season, and many farmers are now employing cocksfoot-timothy and timothy-fescue mixtures. Some farmers use, with success, much lighter seedings—8 or 10 lb. only of grasses, with about 3 lb. of clovers. Good leys are really good—so good as to constitute an embarrassment to the man who has to find the capital to stock them.

A variation of crop succession is introduced where herbage seeds are grown. It has been found that the lias is well suited to herbage seeds. Cocksfoot, ryegrass, timothy and red and white clover seeds are all produced. Lucerne also is coming into general use, though not yet on a sufficient scale to make much showing in the agricultural returns.

Practically all farms carry mixed stocks of cattle and sheep, the latter usually outnumbering the former by about two to one. Stocks are mainly Clun, Kerry or one of the Scottish border crosses ; a good many store lambs are imported in the autumn. Practice is so fluid that it is not easy to distinguish clear-cut systems of management, but a broad distinction can be drawn between those on which milk is produced for sale and the remainder.

Milk Selling

The milk-producing farms could seldom be classed as dairy farms in the sense in which that term is understood a little further west. Rather are they farms on which dairy cows are kept, the actual size of the herds being limited to that which can be managed with the greatest convenience (or rather the least inconvenience). Hardly anyone is fully stocked up with cows, and many farmers vary the size of their milking herd from year to year according to the run of prices, their current cowmanship strength, and their estimate of costs of " going T.T." Water is probably the greatest single determinant. On many farms the steers are at present reared to at least 18 months of age.

Rearing and Feeding

Since the advent of the calf subsidy there has been some increase in calf-rearing. Few are reared on the one cow one calf principle. Multiple suckling is usual, though pail feeding is not uncommon.

Although large numbers of stores are still imported for summer feeding, there has, in recent years, been a considerable decline in this practice, as witness the June 4 figures for the sample parishes, namely :

Cattle per 100 Acres

	1939	1944	1950
Total cattle—1 yr...	34	45	73
Males —1 yr. ..	—	10	26
1-2 yr...	—	9	15
2 yr. +..	—	43	32

The vital statistics for 10 milk-selling farms and 10 devoted to rearing and feeding are given below.

Men, Crops and Stock per 100 Acres

	Milk Selling Average acreage 214	Rearing & Feeding Average acreage 255
Farmers	0.5	0.4
Workers	2.2	1.3
Tillage	44	36
T.G.	14	19
P.G.	41	45
Cows	18	6
Other Cattle	19	32
Sheep	26	48
C.E.	34	32
Acreage Fodder Crops per C.E.	2.5	2.6

Worcester

Worcester's history is very different from that of Warwickshire. From earliest times it has been thickly peopled, perhaps because of its equable climate and prevailing soil fertility.

The lias shows every degree of agricultural development. On the one hand, it is used for intensive market gardening; some of the famous Evesham Vale vegetable growing is carried out on this unkindly soil. At the other extreme are the small stock farms ; on these every difficulty encountered in cultivation of larger farms is magnified by the smallness of the fields and the low scale of capitalization. Hedgerow and headland waste is considerable ; birds are a sore trial at seed-time and harvest ; the number of fields available for cultivation on individual holdings is small. Inevitably the smallholder has to depend for his main cultivations on contractors ; very often he is in the same boat at harvest time.

Prior to the war these farms were poorly stocked, pastures were dominated by *agrostis* and *bromus* and some reverted to scrub ; phosphate deficiency was very marked. Even now they do not carry the stock of which they appear capable. On most of them ploughing has been restricted to a few fields which, after continuous use for cereals, are now worked on a short rotation wheat—seeds for hay—oats. Here and there a field can be let for a year to a market gardener for growing Brussels sprouts. Some beans are grown ; here and there a small area of herbage seeds breaks the regular routine. Mainly, however, the ploughed land is kept in a simple 3-course shift which does indeed provide the maximum safe area of bread corn, but leaves a good deal to be desired in respect of stock-feed.

Most holdings are multiple-purpose undertakings. Milk production, rearing of young cattle, wintering or summering of stores, beef feeding, sheep breeding, pigs and poultry keeping, fruit growing, sprouts or other vegetable production are all practised ; and commonly as many as four or five of these enterprises are embraced in one holding. Opportunism

seems to be the keynote of management. On a few farms—perhaps 10 per cent of the whole—sale of milk is a major source of income. Though water supplies are often poor and buildings indifferent, the fundamental problems of these holdings do not differ materially from those of all other dairy farms. Larger areas in rotation with longer leys and ensilage seem plainly desirable.

Where circumstances do not permit of milk sales, stock rearing is usually the primary enterprise. Prior to 1948 the gross income on these farms was deplorably low, and even now it is far below that obtainable in arable or dairy farming.

It is extremely difficult to see how modern techniques can be fully exploited on farms of this type. Little is as yet known of the economic value of leys for store rearing. Even the composition of leys for young cattle is open to some doubt. Spring grass comes slowly on the lias, and leys, particularly rye grass leys, are apt to be overgrazed, with consequent injury to summer production. Good ground cover is esssential to prevent cracking in July-August droughts. Ensilage, too, fails to offer to the stock-rearer the same advantages that it offers to dairy farmers, for buyers do not want yearlings to come out of yards in a fresh condition. The case for high output, even at high cost, is usually fairly easy to justify at present prices of agricultural produce ; but it looks different when the market is as fickle as that for store cattle.

There are easier farms for the adviser to tackle than the little holdings on the Worcester lias.

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